PROCEDURE FOR ENCAPSULATION OF ELECTRONIC DEVICES

FIELD OF THE INVENTION

The present invention relates to organic light emitting diode (OLED) devices. More particularly, the invention relates to an encapsulation procedure for OLED devices.

BACKGROUND OF THE INVENTION

FIG. **1** shows a conventional OLED device **100**. OLED devices can be used as displays in various consumer electronic products, including cellular smart phones, personal organizers, touch screen displays, multimedia equipment and virtual reality products. The basic advantages of OLED devices are low driving voltage, low power consumption, large viewing angle, high contrast, fast response, rugged design and the potential for low manufacturing costs.

The OLED device comprises a functional stack of one or more organic functional layers **110** between a transparent conductive layer **105** and a conductive layer **115**. The functional stack is formed on a transparent substrate **101**. The conductive layers can be patterned to form one or more cells or pixels on the substrate. In operation, charge carriers are injected through the cathodes and anodes for recombination in the functional layers. The recombination of the charge carriers causes the functional layer to emit visible radiation.

A cap **160**, which forms a cavity **145** between it and the pixels, is mounted on the substrate. A sealant **187** is applied around the edges of the cap where it contacts the substrate. The cavity structure is necessary to protect the OLED layer from moisture, oxygen and other environmental influence, and to prevent mechanical interaction between the OLED layer stack and the packaging material, especially when mechanical pressure is applied from the outside.

The process of mounting the cap involves picking up the substrates, aligning the cap with the substrate, applying a sealant and pressing the substrate and cover cap together. The tools and procedures for encapsulation are designed for handling thick rigid glass (0.3–1.1 mm) or metal caps, and are not suitable for handling thin flexible substrate materials that break easily. The amount of mechanical flexibility achieved for the final product is negligible since metal caps and thick rigid glass sheets are used. These devices typically exhibit a thickness of more than 2 mm.

Thin substrate materials exhibit higher mechanical flexibility, and are suitable for small, light-weight and flexible applications. The tools and methods used for thick rigid substrates cannot be used for handling thin substrate materials without major adaptation.

As evidenced from the discussion above, it is desirable to provide an improved procedure designed for handling thin fragile substrates in the production of OLED devices.

SUMMARY OF THE INVENTION

The invention relates generally to OLED devices. In particular, the invention relates to the sealing procedure for device encapsulation, especially OLED devices on ultra thin flexible substrates.

In accordance with the invention, a substrate holder is provided to support the substrate containing the OLED active components. A cover lid is attached to a lid holder. In one embodiment of the invention, the cover lid is kept in place by adhesive tape that loses its adhesive property after a treatment process. In one embodiment, the treatment process comprises heat exposure. In another embodiment, UV radiation is used. Other types of treatment processes are also useful, depending on the adhesives used, e.g. usage of chemicals.

The lid holder is aligned with the substrate holder to place the lid on the substrate. With the use of the adhesive release tape, the fragile thin lid can be placed safely onto the substrate without breakage. In one embodiment of the invention, UV-curable sealant is dispensed on the cover lid before mounting the lid and cured by UV light after placing the lid on the substrate.

The adhesive tape used to attach the cover lid to the lid holder is treated such that it loses its adhesive property. The substrate and lid holders are then separated and the encapsulated OLED device released.

The sealing procedure produces a thin and flexible cavity structure that provides hermetic sealing against oxygen and moisture. Thin or ultra thin glass substrates can be used to provide higher mechanical flexibility than conventional thick glass substrates. The overall OLED device thickness achieved is less than 0.5 mm. The procedure is compatible with sensitive OLED materials and is scalable to cost-effective mass production.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a conventional OLED device;

FIG. **2** shows a thin flexible OLED device;

FIG. **3** shows a substrate holder;

FIG. **4** shows a cover lid holder; and

FIGS. **5–8** show a process for encapsulating an OLED device in accordance with one embodiment of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

FIG. **2** shows a thin flexible OLED device **200** according to one embodiment of the invention. The OLED device comprises a substrate **240** on which active components are formed in the device region thereof. The active components, for example, comprise OLED pixels, segments or other patterns. In one embodiment, the substrate comprises a transparent substrate, such as glass. The substrate, for example, can be made from silicate glass such as borosilicate glass. Other transparent materials, such as plastic, sodalime glass or other types of glass, are also useful. Typically, the thickness of the thin substrate is less than about 0.5 mm, preferably about 0.01–0.2 mm.

The OLED active components **210** comprise one or more organic layers sandwiched between 2 electrodes. A lid **220** is provided to encapsulate the OLED pixels. The lid layer comprises, for example, a metal or glass. Other types of cover lids, which protect the active components from the environment, such as ceramic or metallized foil, are also useful. Typically, the cover lid exhibits a thickness of 0.01 mm to 0.2 mm.

In one embodiment, adhesive **230** is used to mount the lid. Adhesives such as self-hardening adhesives, UV or thermal curable adhesives, or hot melt adhesives are useful. Other techniques that employ low temperature solder materials, ultrasonic bonding, or welding techniques using inductance or laser welding are also useful.

A substrate holder and a lid holder are provided to handle the thin fragile substrate and cover lid. Referring to FIG. **3**, a substrate holder **300** with alignment pillars **330** is pro-